Landsat 7 Processing System CDR

• Introduction	J. Henegar
• Design Overview	R. Schweiss T. Aslam
• LPS Hardware Architecture	C. Brambora
• LPS Operational Scenarios	R. Schweiss
• SWCI Detailed Design	J. Hosler D. Crehan
• System Testing	J. Henegar
• Acceptance Testing	EDC
• Facilities	EDC
• Conclusion	J. Henegar

- **Overview**
- **System Startup / Shutdown**
- **Operations Interface**
- **Automatic Data Capture**
- **Raw Data Capture**
- **Level 0R Processing**
- **Manage Output File Transfer**
- **LPS Database**

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Design Methodology

- **SSDM Structured Design Methodology**
  - **Top Down Design**
  - **Preliminary: Completed through top two levels**
  - **Detailed: Completed through lowest levels**
- **LPS Project Standards**
  - **On-line Documentation**
  - **Procedures**
  - **Conventions**
  - **CADRE / Teamwork**
    - » **Software Requirements**
    - » **Structured Design**
    - » **Requirements Traceability**

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Issues

- The LPS output file formats are continuing to refine and have not been approved, therefore, HDF has not been incorporated into the current design
- The Automatic Cloud Cover Assessment (ACCA) algorithm has not been provided
- The Operations Interface (OIF) design is ongoing with input from EDC personnel, including status and error message specification
- The latest revision of the LPS - LP DAAC (ECS) ICD has not been incorporated into the current design
- The current Landsat 7 DFCB has known deficiencies that could result in changes to the current design
- Long term reporting requirements have not been defined

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Assumptions

- **The spacecraft clock will not be updated during imaging**
- **The current scene determination algorithm meets the WRS framing accuracy requirements**
- **System times on all LPS strings are synchronized with UTC**

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Design Drivers/Constraints

- **Cost**
  - Predominantly Software Architecture
  - Software Isolated to a Single String
  - Software Reuse / COTS
    - » Renaissance Building Blocks
    - » LPS internal
    - » 4GL for building the LPS Operations Interface (OIF)
    - » 4GL for building the LPS report generation routines
- **Performance**
  - Pipe-line processing for Level 0R processing
- **Raw Data Capture Reliability**
  - Raw Data Capture will execute with or without the database

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Principal Functions

- **Raw Data Capture**
  - Receive Raw Wideband Data from LGS
  - Generate the Data Receipt Summary Report
  - Backup / Restage / Delete Raw Data Files
  - Provide Data Transmission for Testing Purposes
- **Level 0R Processing**
  - Perform CCSDS Grade 3 AOS Processing
  - Perform Error Detection and Correction (CRC, RS, BCH)
  - Build ETM+ Major Frames
  - Deinterleave and Reverse Bands
  - Build PCD Cycles
  - Identify Scenes
  - Collect Metadata Q/A Statistics

- **Level 0R Processing (Cont.)**
  - Generate Output Files
  - Provide a “Moving Window Display”
  - Generate Level 0R Q/A Report
- **Manage Output File Transfer**

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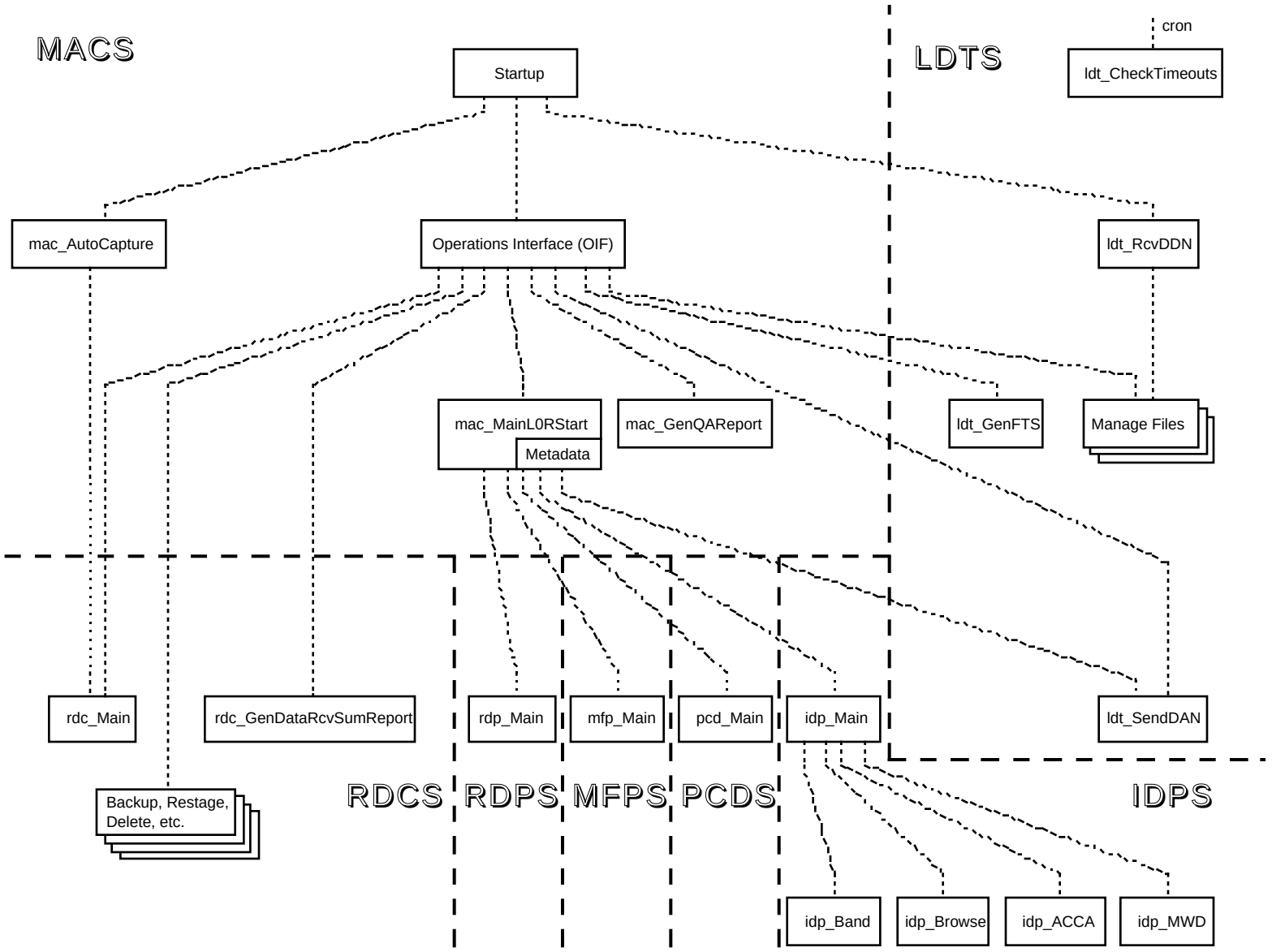
Top Level Architecture



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System Startup / Shutdown

- **Start up LPS String**
  - Start Oracle DBMS processes
  - Start LPS transfer timeout daemon
- **Start up LPS Software**
  - Check on-line files against LPS database
  - Start automatic capture and DDN server daemons
  - Display Operations Interface menu
- **Shutdown LPS Software**
  - Shut down automatic capture and DDN server daemons
  - Exit Operations Interface menu
- **Shutdown LPS String**
  - Shut down LPS transfer timeout daemon
  - Shut down Oracle DBMS processes

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Operations Interface: Design Approach

- **Maximize functionality within constrained budget**
  - **Oracle Forms 4.0 GUI builder**
  - **UNIX services and utilities**
  - **X Windows/Motif**
- **Minimize OIF / Applications interface complexity**
- **All functions available from GUI and UNIX shells**
- **Extensive status/error reporting with filtering for display to operator**
- **Incorporate feedback from hands-on prototypes**

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Operations Interface: Environment

- **Operations interface hardware**
  - **2 operations interface workstations (SGI Indy)**
  - **2 X terminals**
  - **OIF executes on LPS string**
  - **String OIFs can be displayed on any subset of the hardware**
- **Operator user type**
  - **Single operator account with standard user privileges**
  - **Data capture runs with effective UID = root**
- **Administrative user operations and privileges handled by system software**
  - **System administration**
  - **Database administration**

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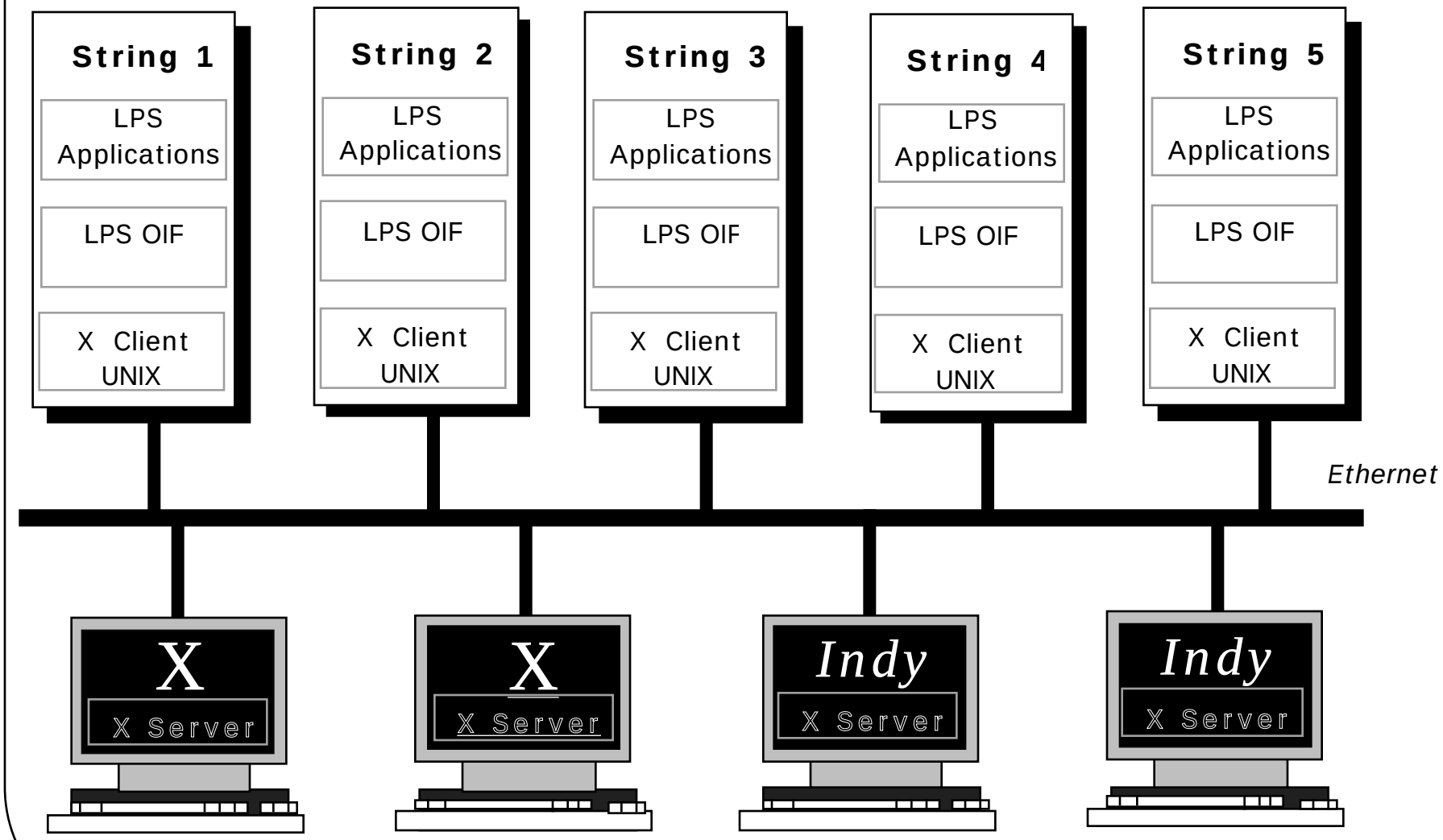
Operations Interface: Environment



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Operations Interface: Architecture (1 of 2)

- **Command interface**
  - **Accept operator commands and forward to LPS applications**
- **Application message interface**
  - **Accept application messages and log in LPS journal**
- **Monitor interface**
  - **Display application messages as they are logged**
  - **Browse LPS journal**

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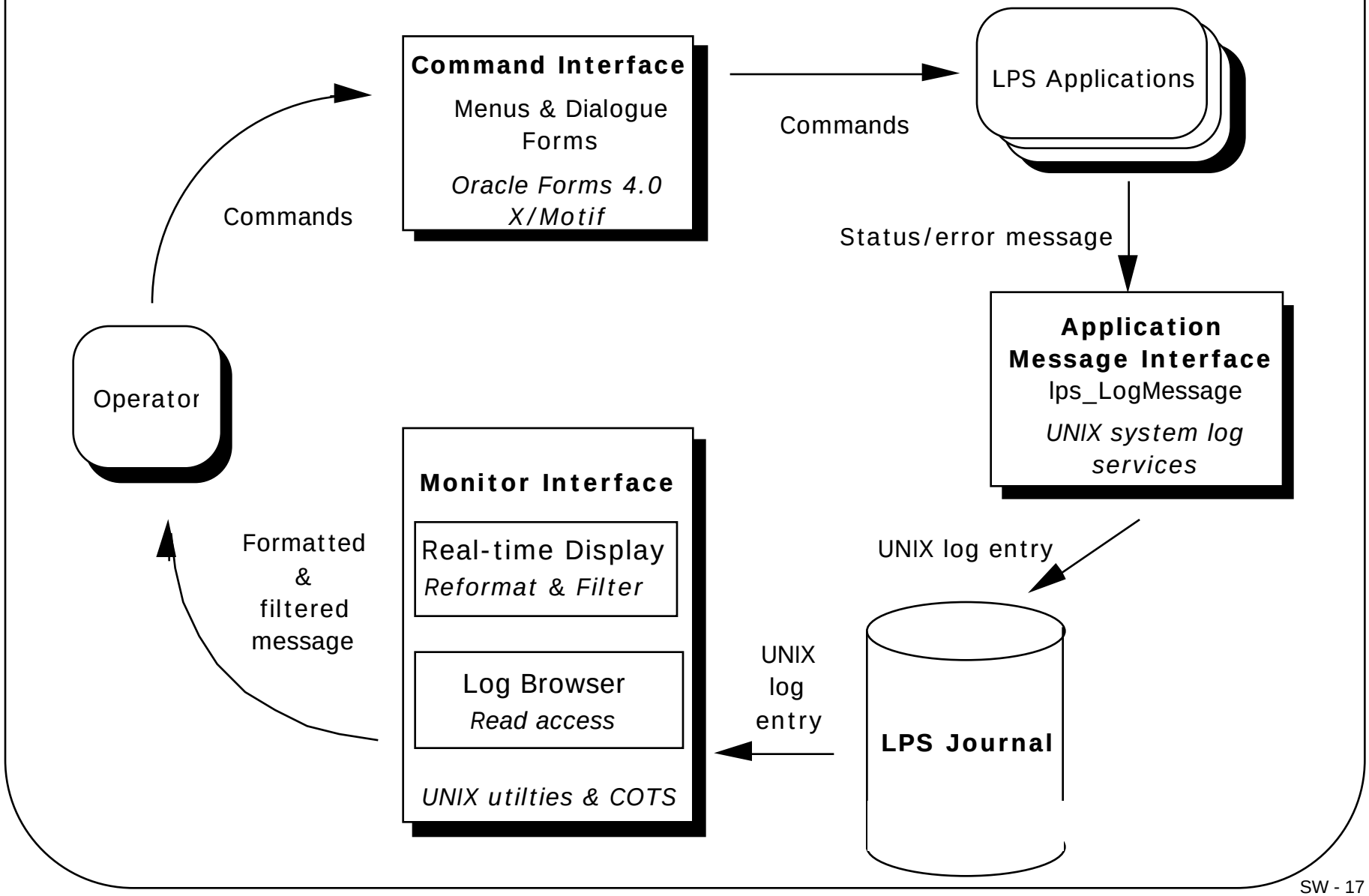
Operations Interface: Architecture (2 of 2)



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Operations Interface: Command Interface

- **Pull down menus**
  - **Setup**
  - **Control**
  - **Reports**
  - **Test**
  - **File Management**
  - **Shutdown**
- **Input dialogue forms accept additional parameters**
  - **Validation by LPS application**
- **Oracle Forms 4.0 / X / Motif**

- **Global function - lps_LogMessage**
  - Accepts message, severity, unit name, and line number
  - Formats journal entry and logs to LPS journal
  - Application error messages limited by operator-specified thresholds
- **UNIX system log services**
  - Allows use of COTS browsers
  - Allows integration of UNIX messages with LPS application messages (e.g. ftp connections from LP DAAC)
  - Automatic time tagging
  - Simple, flexible message routing by severity and facility to files, console, and on-line users
- **Optional message display to UNIX stderr**

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Operations Interface: Monitor Interface

- **Real-time journal display**
  - **Reformats and displays messages as they are logged**
  - **Scrolling display with font/color changes and audible alarm for severe errors**
  - **Messages filtered by operator specified severity value**
  - **Multiple instances can display nominal, critical messages**
  - **UNIX utilities for window management, scrolling, fonts, audible alerts, etc (prototype = ~ 39 DSI)**
- **Journal browser**
  - **Read access to LPS journal**
  - **SGI system log viewer (sysmon) is candidate implementation**

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Automatic Data Capture: Design (1 of 2)

- **Contact schedule update form**
  - **Review and update contact schedule**
- **Automatic data capture daemon**
  - **Fetch next scheduled contact start time from LPS database**
  - **Wait**
  - **Invoke RDCS raw data capture program (rdc_Main)**
  - **Monitor rdc_Main's execution**
- **Operator override**
  - **Menu options start/shutdown daemon**
- **Contact schedule updates signal daemon to reread database**

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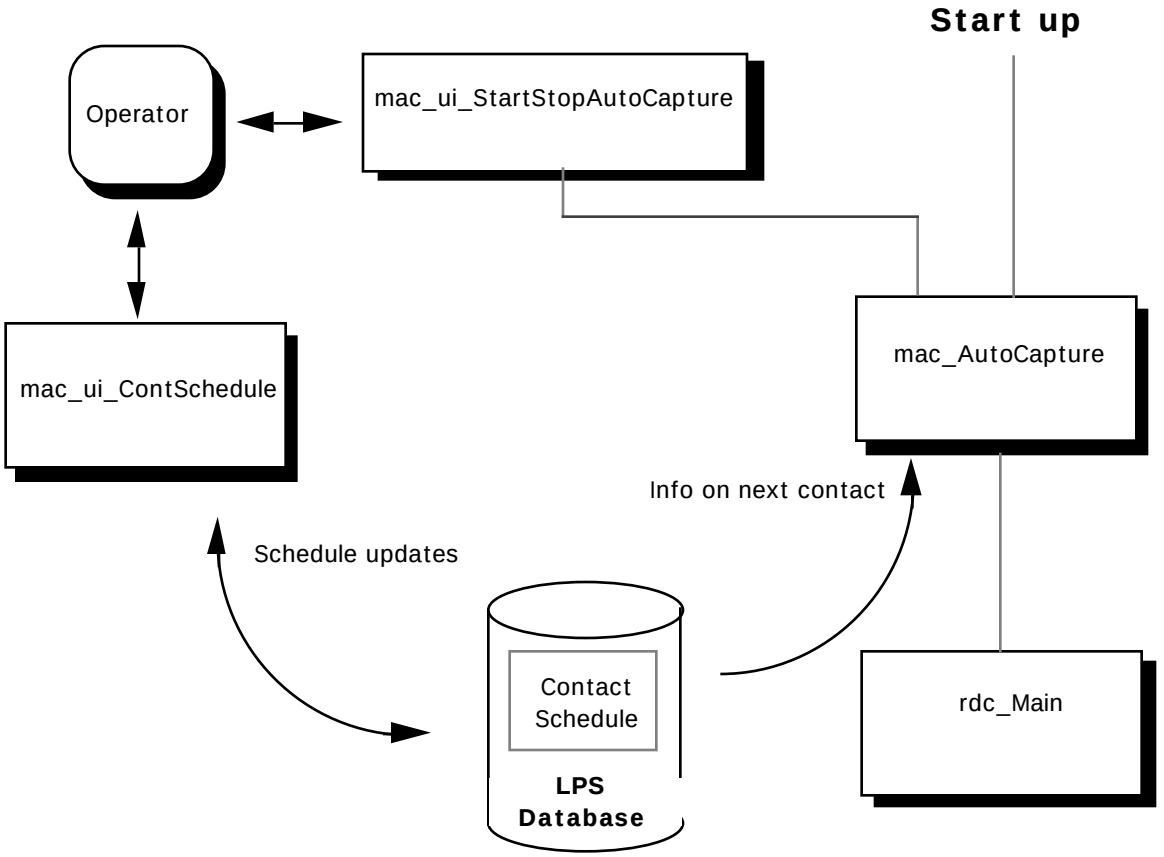
Automatic Data Capture: Design (2 of 2)



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Raw Data Capture: Overview

- **Captures raw wideband data and performs raw data file management**
- **Principal Functions**
  - **Receipt of Raw Wideband Data**
  - **Generate the Data Receipt Summary Report**
  - **Storing the Raw Wideband Data to the 30-day store**
  - **Deletion of the Raw Wideband Data from the front-end disk array**
  - **Restaging the Raw Wideband Data from the 30-day store**
  - **Generate Tape Labels**
  - **Provide data transmission in support of testing**

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Raw Data Capture: Interfaces

- **Receipt of Raw Wideband Data from LGS**
- **Invocation to RDC main driver (rdc_Main) from MACS automatic capture program (mac_AutoCapture)**
- **Operator commands from the MACS OIF or from the operator's OS shell**
- **Raw Data Capture accounting / filename to database**
- **Tape label information to label printer**

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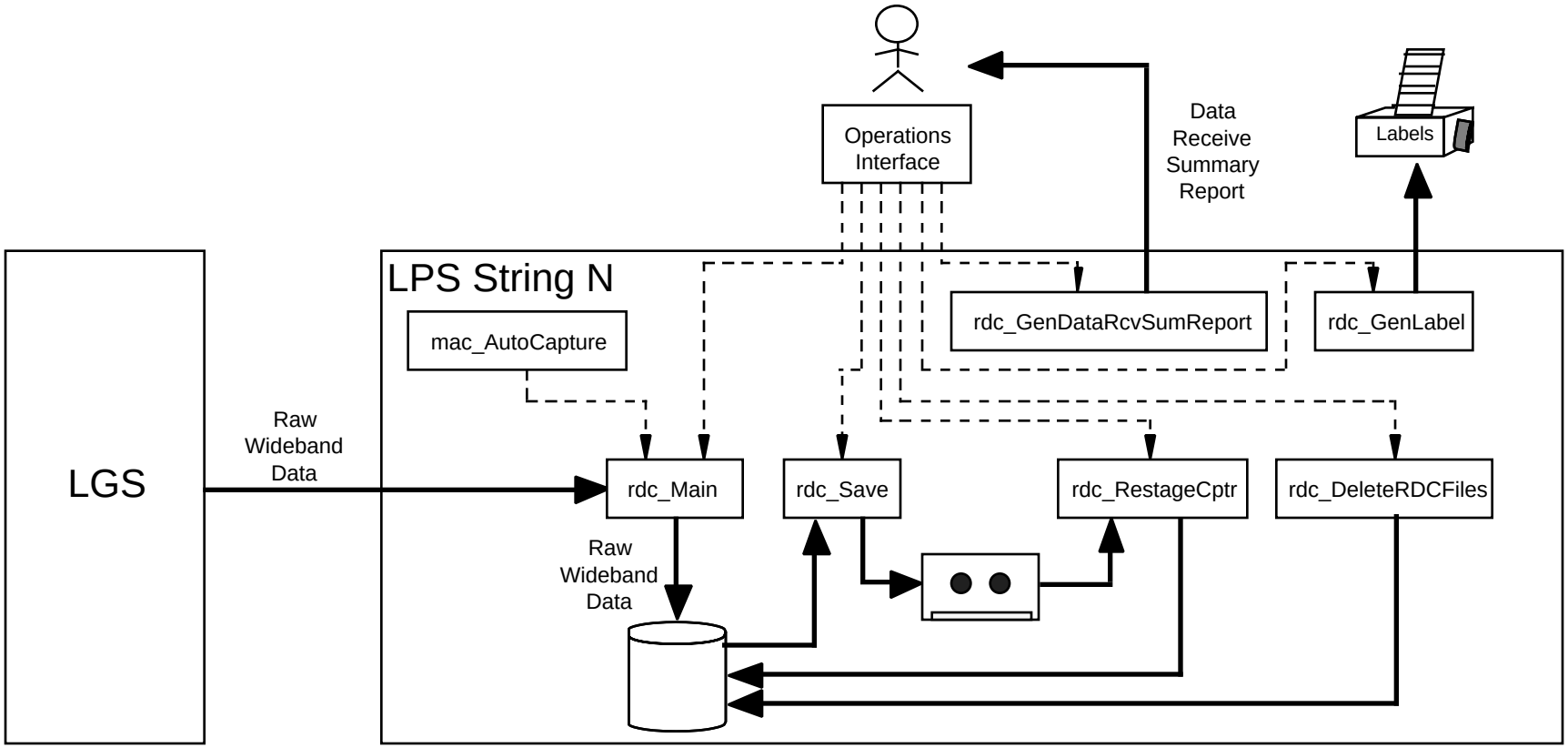
Raw Data Capture: Interfaces



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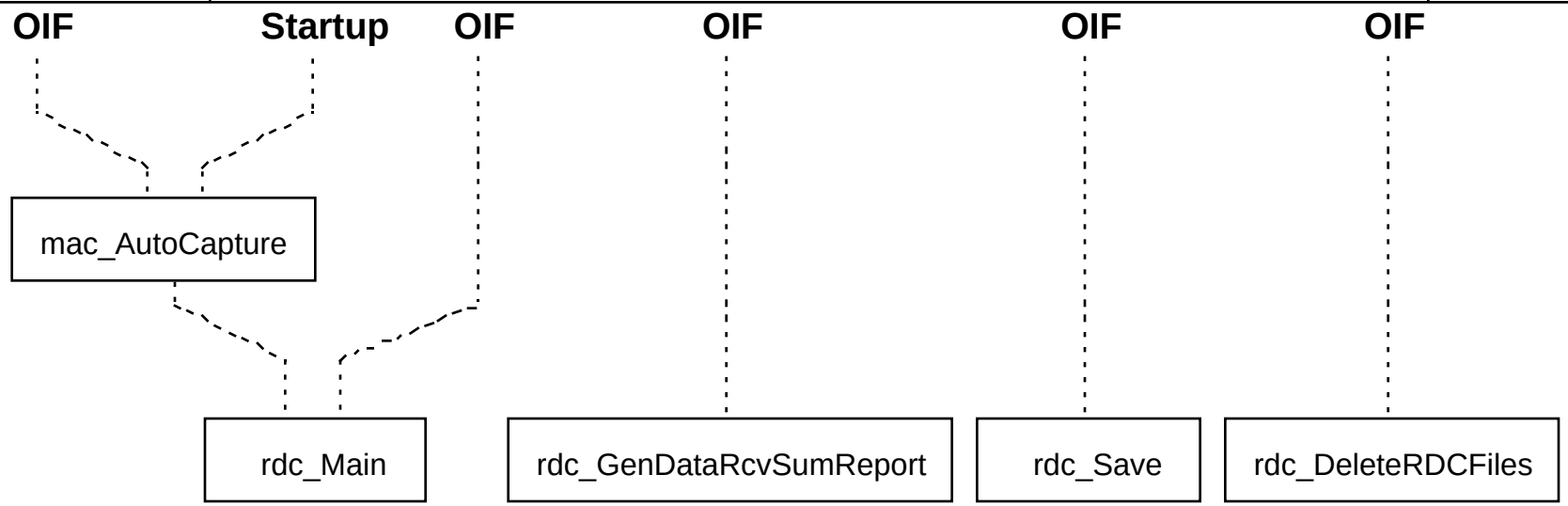
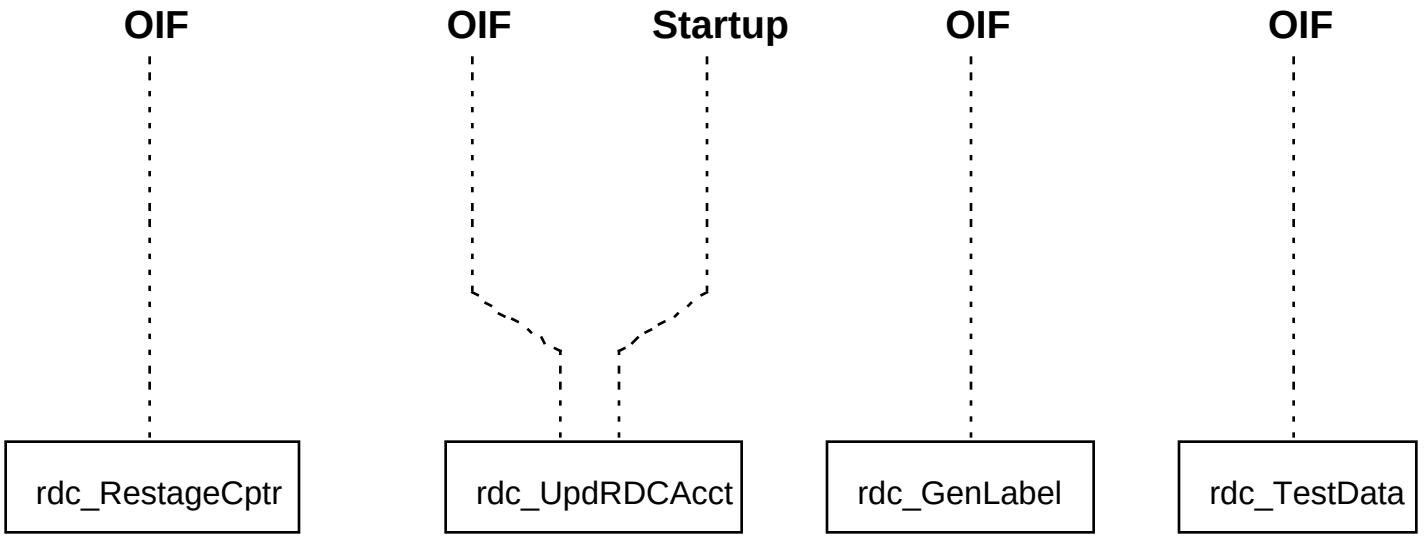
Raw Data Capture: Process Structure





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Raw Data Capture: Design (1 of 2)

- **RDC Main Driver (rdc_Main)**
  - Performs initialization of process immediately upon invocation
  - Checks for disk space availability and notifies operator if necessary
  - Suspends L0R processing
  - Captures raw wideband data and places into a disk file until clock and data from LGS stops after the scheduled stop time
  - Calculates data receive statistics
  - Stores the data receive statistics into a raw data accounting file and the LPS database
- **RDC Features**
  - Minimal resources are required
  - Effective UID = root
  - Normally suspends L0R processing

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Raw Data Capture: Design (2 of 2)

- **Data Receive Summary Report Generation (rdc_GenDataRcvSumReport)**
- **Raw Data File Backup (rdc_Save)**
- **Raw Data File Deletion (rdc_DeleteRDCFiles)**
  - **Upon completion of L0R processing, the operator can choose to delete the raw data file automatically, or deletion can be done manually**
- **Raw Data File Restage (rdc_RestageCptr)**
- **Tape Label Generation (rdc_GenLabel)**
- **Test Data Transmission (rdc_TestData)**

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- **Perform Level 0R Processing on a Raw Wideband Data File**
- **Principal Functions**
  - **Process a raw wideband data file to L0R output files**
    - » **Calibration**
    - » **Mirror Scan Correction Data**
    - » **Payload Correction Data**
    - » **Band**
    - » **Browse**
    - » **Metadata**
  - **Provide a “Moving Window Display”**
  - **Notify the LP DAAC that L0R processing is complete**
  - **Generate a L0R Q/A report**

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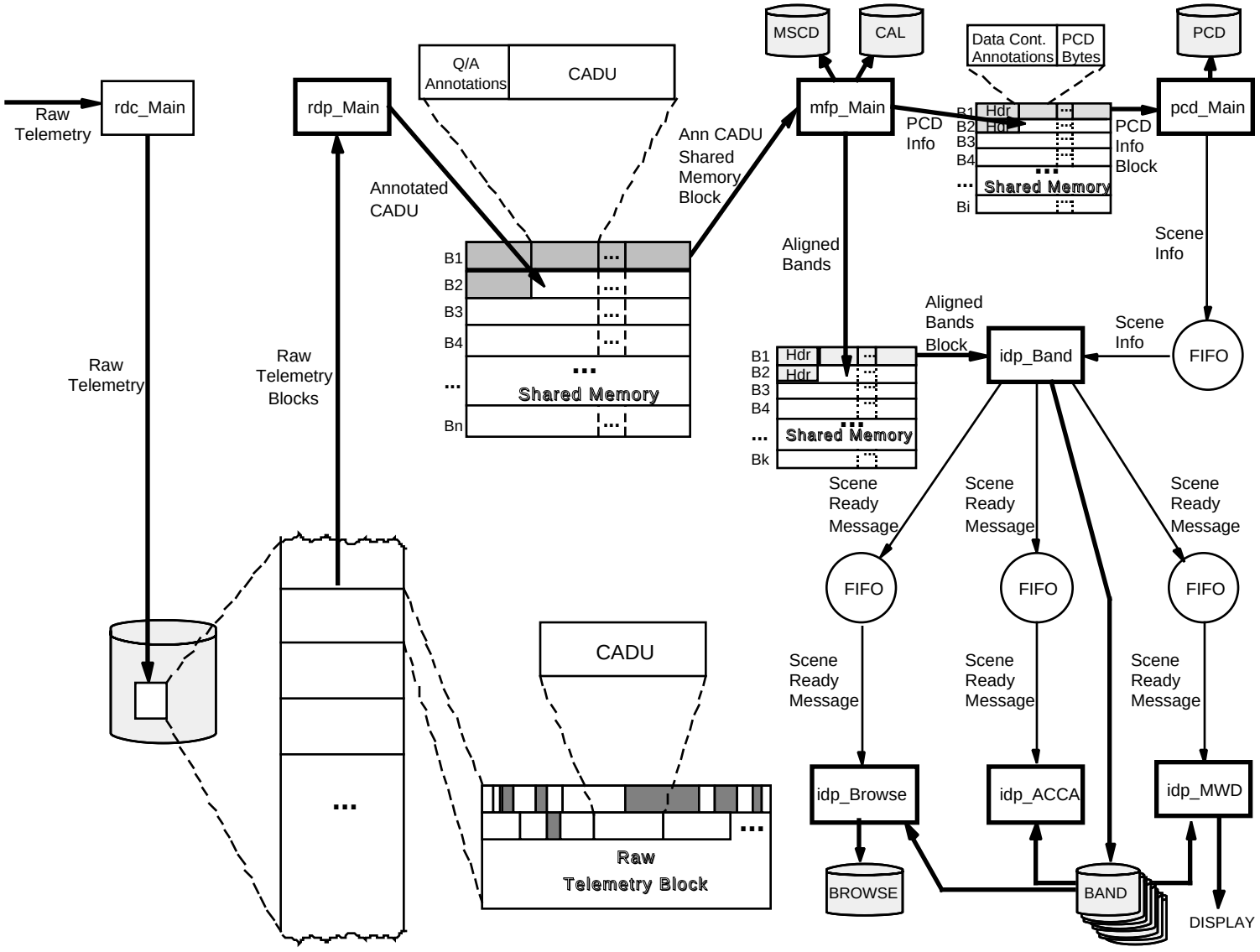
L0R Processing: Interfaces



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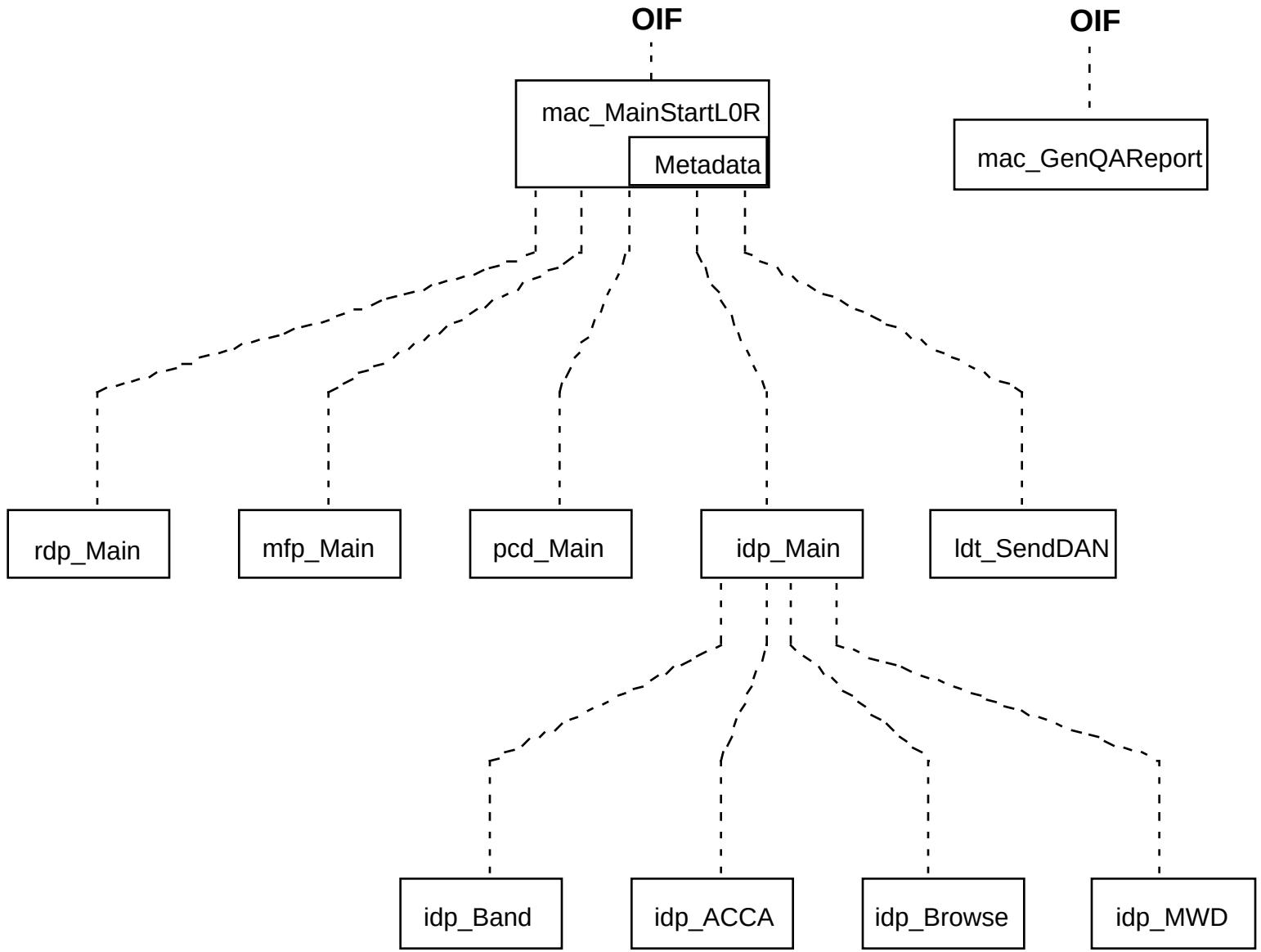
L0R Processing: Process Structure



- **MACS L0R process manager (mac_MainStartL0R)**
  - **Allocates and deallocates all L0R shared resources**
  - **Asynchronously invokes the L0R processing subsystems and monitors their status**
    - » **Raw Data Processing (rdp_Main)**
    - » **Major Frame Processing (mfp_Main)**
    - » **Payload Correction Data Processing (pcd_Main)**
    - » **Image Data Processing (idp_Main)**
  - **Generates Metadata files**
  - **Removes any L0R processed subinterval files smaller than a scenes worth of data**
  - **Invokes the LDTS Send DAN process (ldt_SendDAN) to notify the LP DAAC that L0R processing is complete.**
  - **In the event L0R processing is aborted prematurely, the MACS removes database entries and L0R output data files produced by the L0R processing subsystems.**

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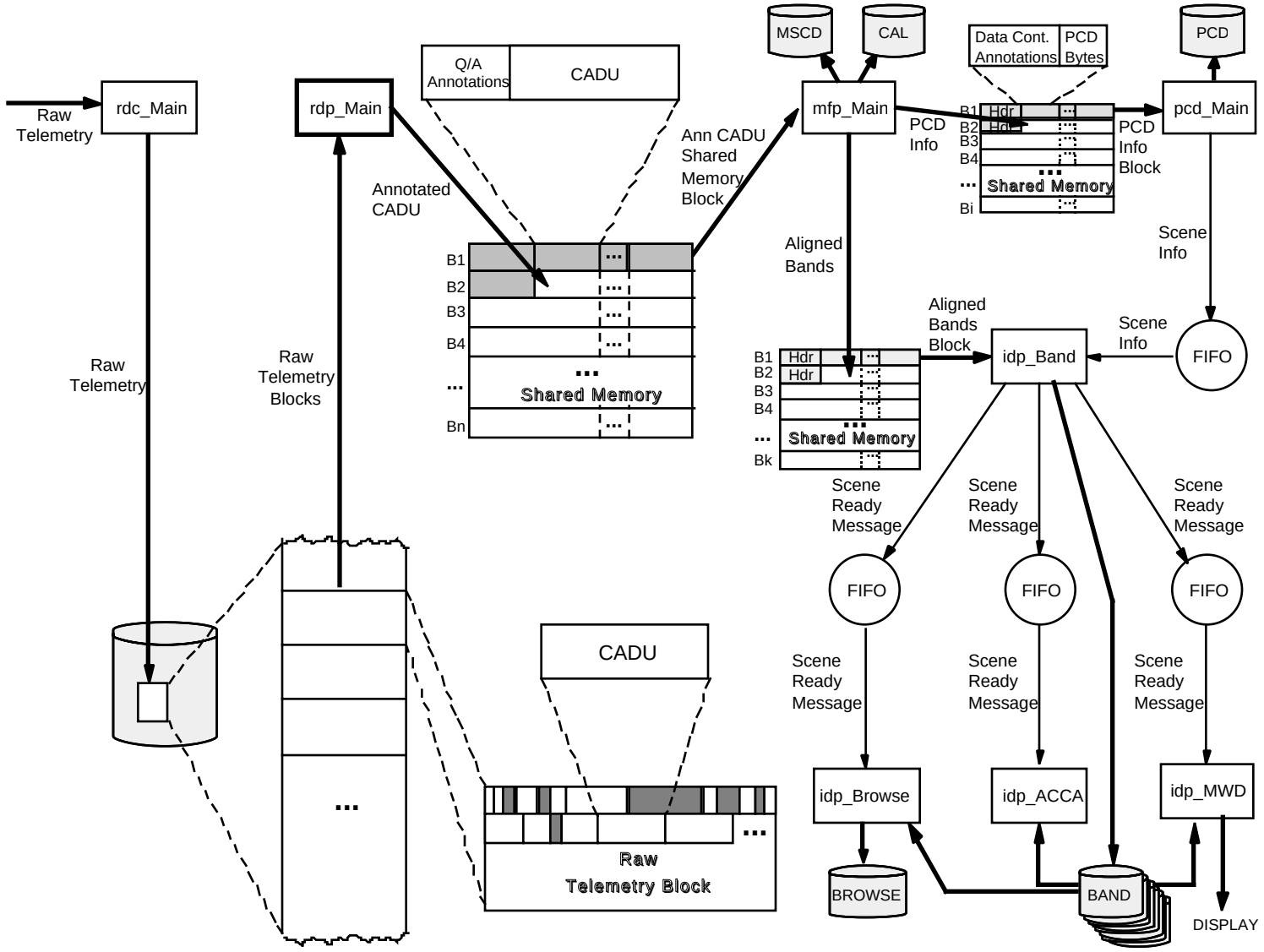
L0R Processing: Interfaces



- **Raw Data Processing Main Driver (rdp_Main)**
  - Extracts data blocks from the Raw Wideband Data file produced by the RDCS
  - Performs a Search / Lock / Check / Flywheel (SCLF) frame synchronization, byte alignment, deinversion, and PN decoding on the extracted data blocks to identify the CADUs
  - Annotates the CADUs with frame synchronization information
  - Places the annotated CADUs into a shared memory segment
  - Performs CRC on the CADUs in shared memory and annotates them appropriately
  - Performs Reed-Solomon (RS) error detection and correction on the CADUs in shared memory for up to two code blocks and annotates them appropriately
  - Performs BCH error detection and correction on the CADUs in shared memory for up to three code blocks and annotates them appropriately
  - During processing, maintains return link Q/A information and stores it into the database for Level 0R Q/A report generation

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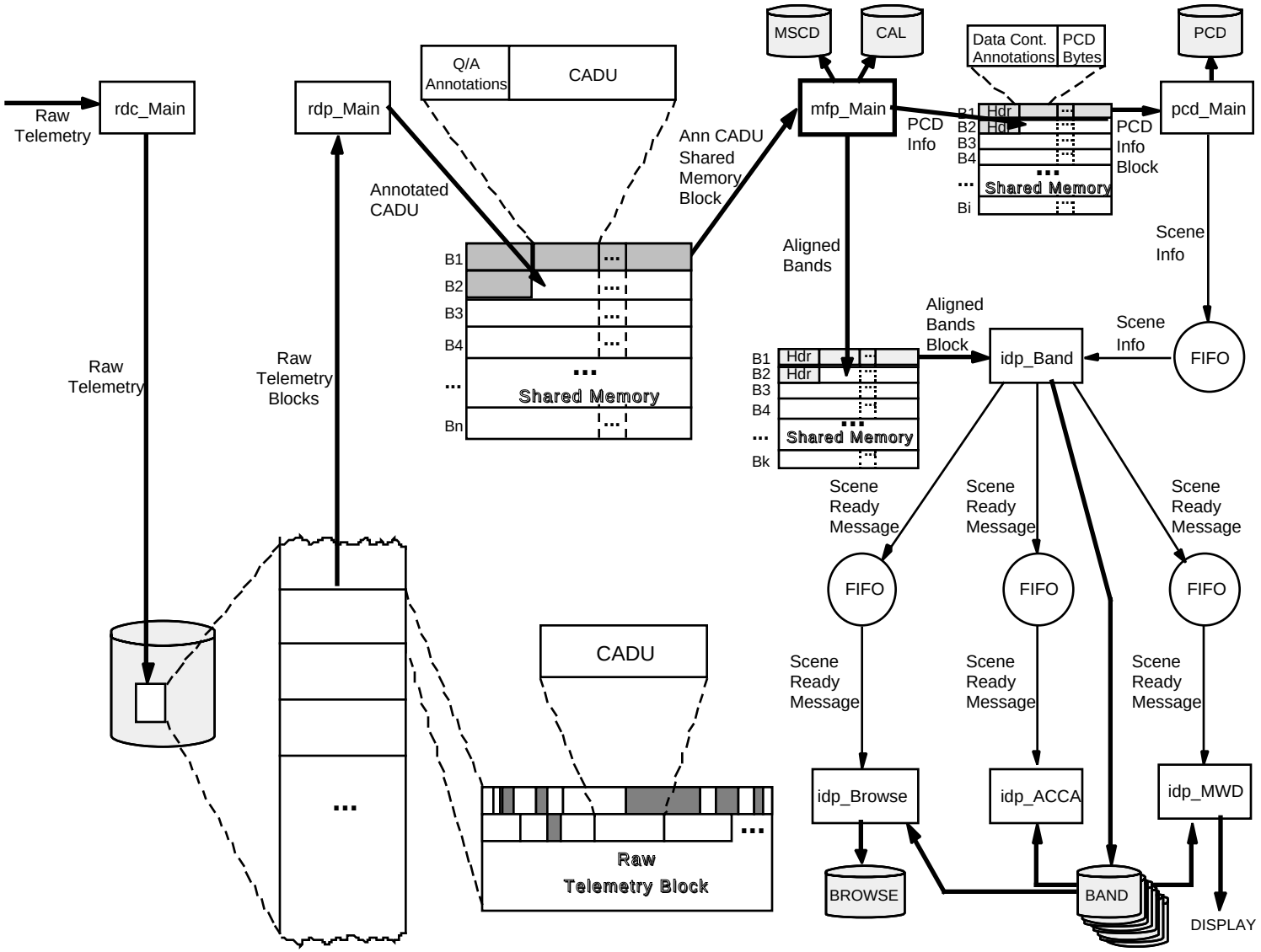
L0R Processing: Interfaces



- **Major Frame Processing Main Driver (mfp_Main)**
  - **Extracts CADUs from the shared memory segment from RDPS**
  - **Validates the ETM+ major frames by locating the minor frames with the synchronization marker, major frame time, end-of-line code, scene data, calibration data, and Mirror Scan Correction Data (MSCD)**
  - ***Determines the start and stop of the subintervals*** **and stores the subinterval information into the database**
  - **Extracts the PCD bytes from the CADUs and forwards them to PCDS**
  - **Extracts the status information from the CADUs and forwards them to IDPS**
  - **Generates the Calibration and MSCD files and stores the names into the database**
  - **Deinterleaves, reverses, and aligns the bands and then forwards them to IDPS**
  - **Maintains Q/A statistics during processing, and stores the results into the database on a subinterval basis**

- **Subinterval Break Conditions**
  - **VCID change**
  - **End-of-Contact**
  - **A major frame time jump exceeding some predefined tolerance**
  - **A VCDU counter jump exceeding a tolerance derived from the time jump tolerance**

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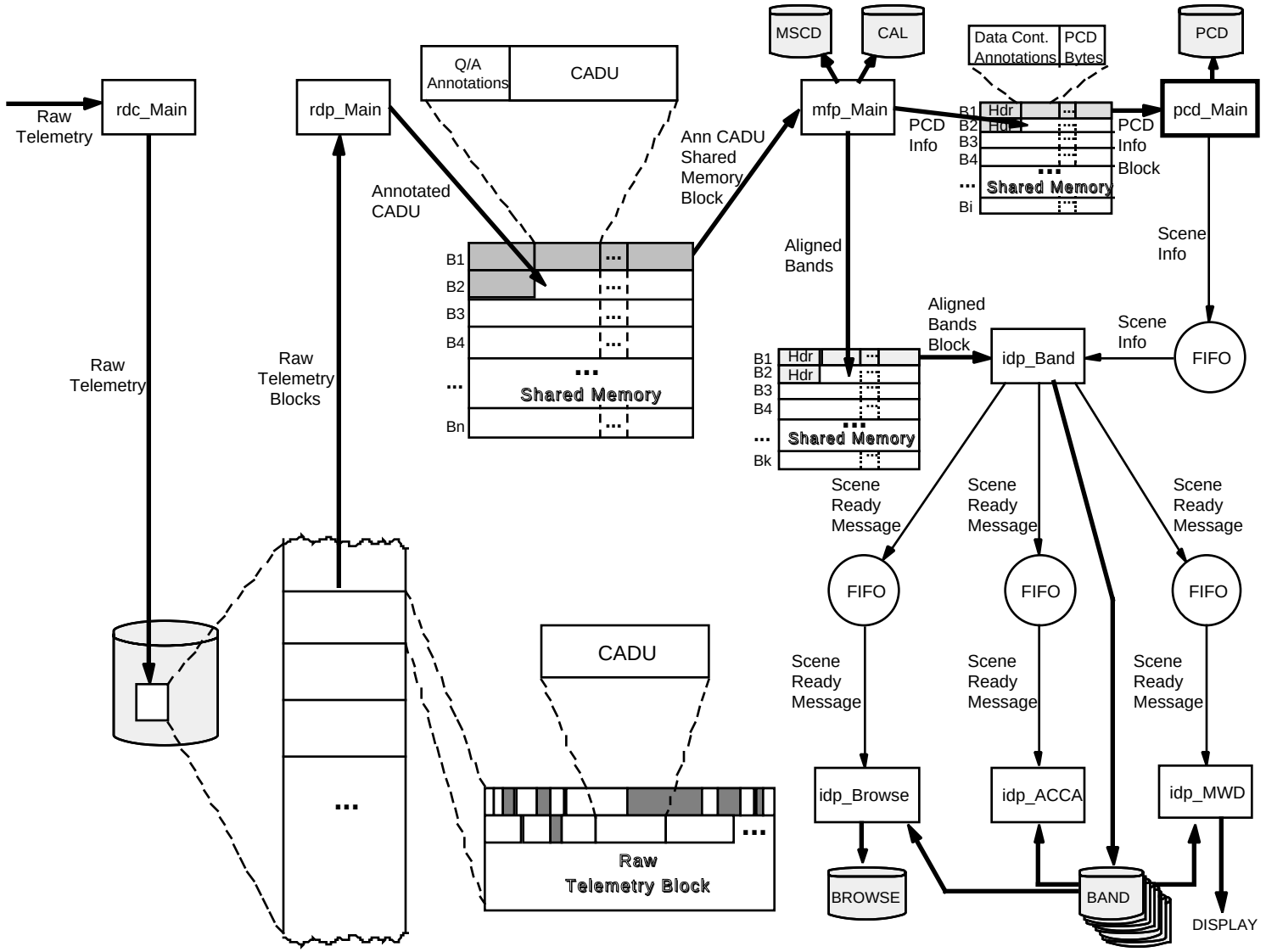
L0R Processing: Interfaces



- **PCD Processing Main Driver (pcd_Main)**
  - **Extracts the PCD bytes from the shared memory segment with MFPS**
  - **Assembles the PCD words and locates the PCD synchronization words**
  - **Performs a *majority vote* on the PCD data words to assemble a PCD data word buffer**
  - **Performs a minor frame synchronization on the PCD data word buffer to identify the PCD minor frames**
  - **Assembles the PCD major frames from the PCD minor frames**
  - **Assembles the PCD cycles from the PCD major frames (MF 0-3)**
  - ***Determines the scene centers* from the assembled PCD cycles and provides them to IDPS through a FIFO mechanism**
  - ***Determines the PCD subintervals*, and places the assembled PCD cycles into the appropriate subinterval PCD file**
  - **Calculates the orbit number**
  - **Upon processing the contact to completion, the scene information is stored into the database for metadata generation.**

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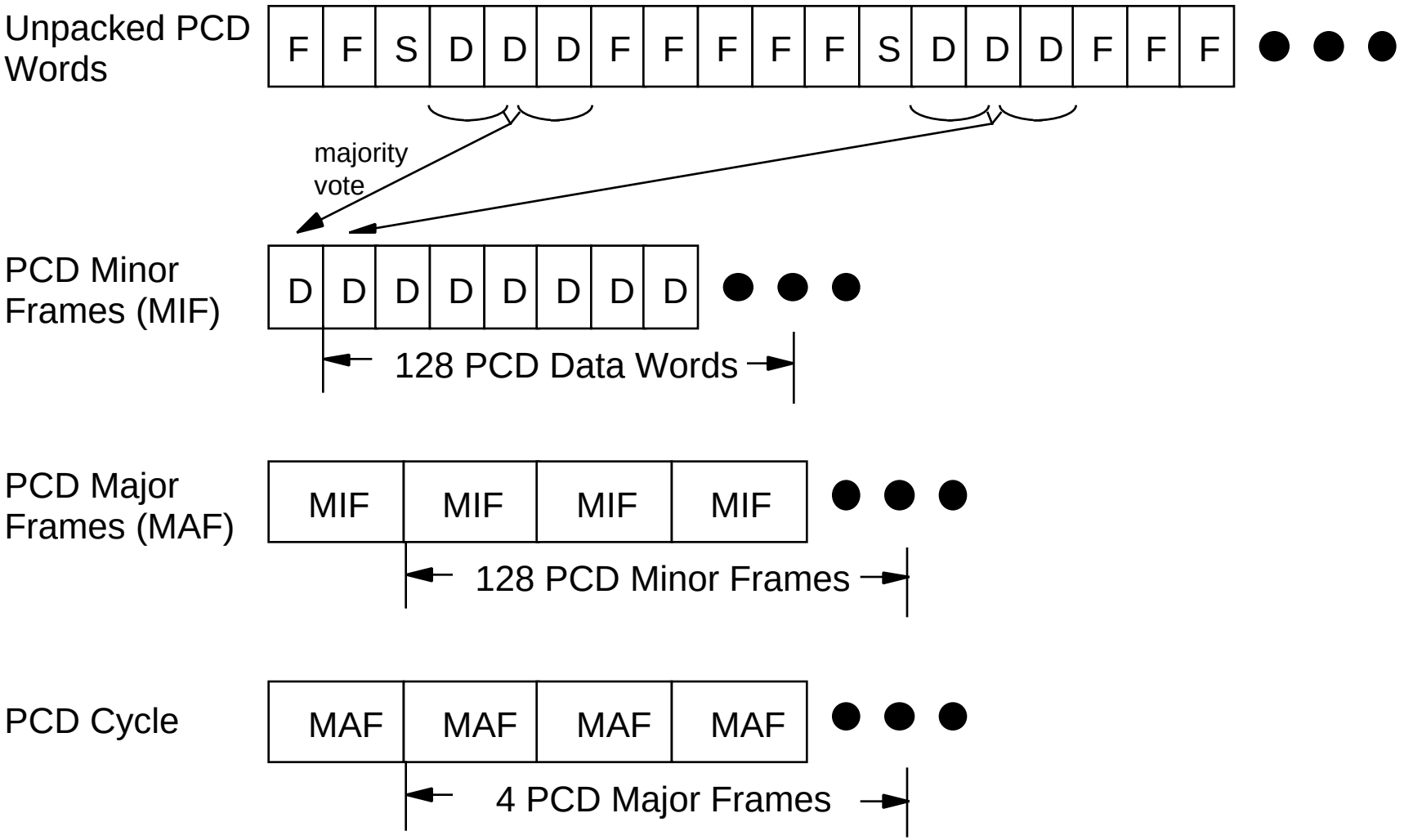
L0R Processing: Unpacked PCD



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L0R Processing: Design (7 of 13)

- **PCD Data Word Majority Vote**
  - All three words are different; first chosen
  - Two are equivalent, one different; equivalent chosen
  - Three are equivalent; equivalent chosen
- **Scene Determination**
  - Extract the ephemeris, attitude, full aperature calibration status, and the spacecraft time (UTC) from each PCD cycle
  - Interpolate the missing ephemeris and attitude data
  - Compute the ephemeris and attitude time from the spacecraft time
  - Compute the latitude and longitude of the view point
  - Retrieve the first WRS scene center from the database
  - Interpolate the actual scene center from the latitude and longitude of the view points
  - Compute the horizontal display shift
  - Compute the sun azimuth and sun elevation angles
  - Report the scene description to the IDPS and the database

- **PCD Subinterval Determination**
  - **Data continuity annotations are received from MFPS associated with each set of 4 PCD bytes**
    - » **VCID Change Flag; signifies that there was a VCID change in the VCDU where the PCD bytes were extracted**

      When this flag is set, a PCD subinterval break is declared
    - » **Data Break Flag; signifies that there was a data dropout exceeding some predefined tolerance prior to the current PCD bytes**

      When this flag is set, a PCD subinterval break is declared
    - » **Missing VCDU Count; signifies that there were missing VCDUs prior to the current PCD bytes**

      When there are missing VCDUs, the associated PCD bytes are filled, but does not force a subinterval break
  - **Upon assembly of the PCD cycles, a backward PCD cycle time jump will cause a PCD subinterval break to be declared.**

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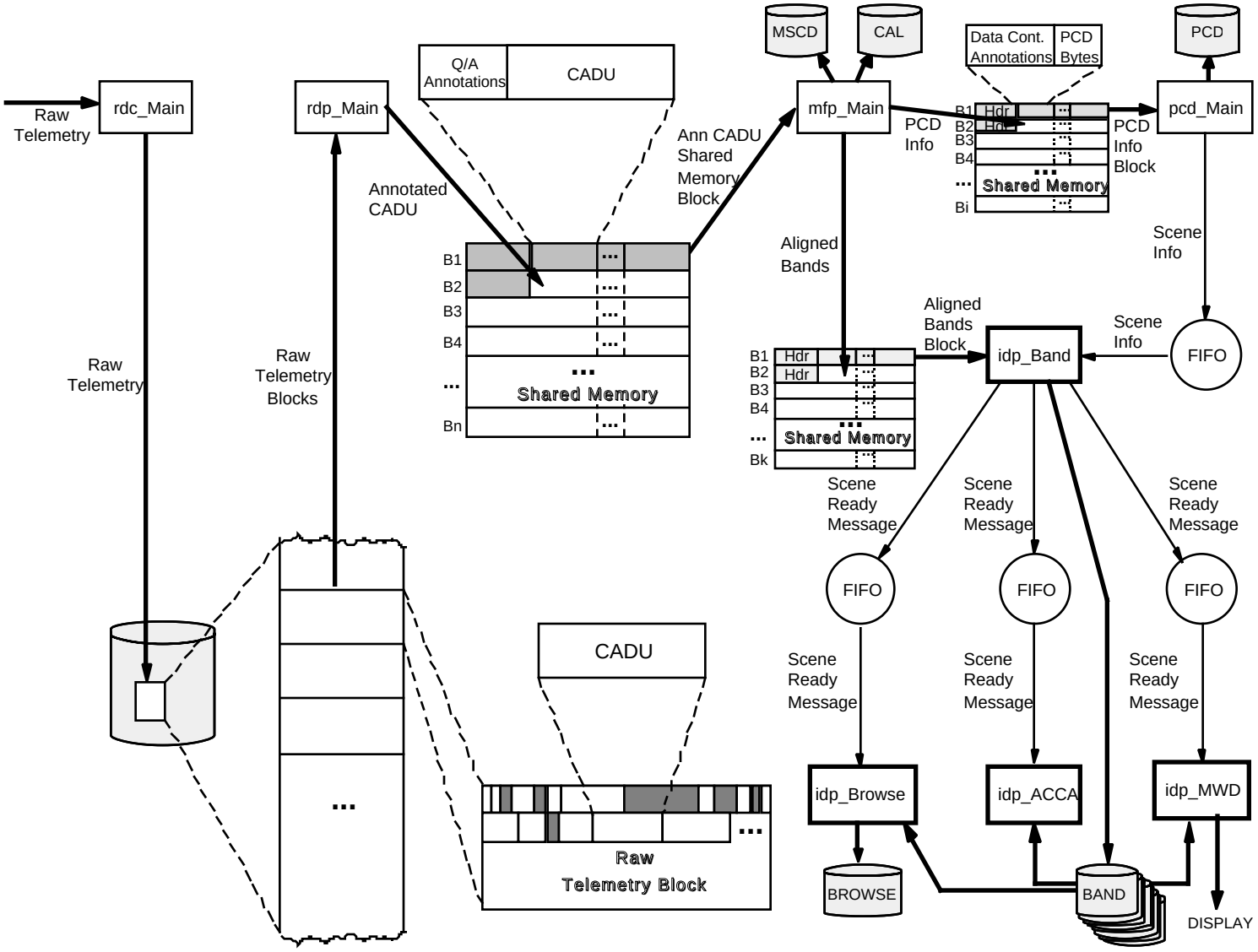
L0R Processing: Interfaces



- **Image Data Processing Main Driver (idp_Main)**
  - **Asynchronously invokes the IDPS child processes upon startup to process the first subinterval**
    - » **Band File Generation (idp_Band)**
    - » **Browse File Generation (idp_Browse)**
    - » **Automatic Cloud Cover Assessment (idp_ACCA)**
    - » **Moving Window Display (idp_MWD)**
  - **Waits for the completion of the child processes**
  - **The IDPS child processes are invoked for continuously for each subinterval until the Band File Generation process returns a value indicating that the end of contact has been processed**
  - **In the event of abnormal termination of an IDPS child process, all currently running children are aborted, and the main driver returns a failure status to the calling process**

- **Band File Generation (idp_Band)**
  - Extracts the Aligned Bands from the shared memory segment with MFPS.
  - Reads the scene information from the FIFO mechanism provided by PCDS
  - Creates the Band Files based upon the format provided by MFPS
  - Stores the Band Filenames into the database and provides the filenames and the format to the Browse, ACCA, and MWD processes via independent FIFO mechanisms
  - Reads the Aligned Bands from MFPS and writes them to the appropriate Band File
  - When a scene center is located, notifies the Browse, ACCA, and MWD processes that a scene is available
  - When MFPS signifies a subinterval change, the Browse, ACCA, and MWD processes are notified, the Band Files are closed out, and this process exits.
  - During processing of the subinterval, metadata information is maintained and stored to the database.

- **Browse File Generation (idp_Browse)**
  - Waits for the first message from the Band Generation process (idp_Band)
  - If the ETM+ telemetry is format 2 then this process exits
  - Attaches to the identified Band Files for reading
  - Waits for the next message from the Band Generation process
  - When a full scene has been identified, then a browse file for the scene is generated
  - Continues to process messages from the Band Generation process until a subinterval change is specified
  - When a subinterval change is specified, this process stores the filenames into the database and exits

Landsat 7 Processing System CDR

L0R Processing: Design (12 of 13)

- **Automatic Cloud Cover Assessment (idp_ACCA)**
  - **Waits for the first message from the Band Generation process (idp_Band)**
  - **If the ETM+ telemetry is format 2 then this process exits**
  - **Attaches to the identified Band Files for reading**
  - **Waits for the next message from the Band Generation process**
  - **When a full scene has been identified, then cloud cover scores for the scene are generated**
  - **Continues to process messages from the Band Generation process until a subinterval change is specified**
  - **When a subinterval change is specified, this process stores the cloud cover scores into the database and exits**

Landsat 7 Processing System CDR

L0R Processing: Design (13 of 13)

- **Moving Window Display (idp_MWD)**
  - **Waits for the first message from the Band Generation process (idp_Band)**
  - **Attaches to the identified Band Files for reading**
  - **Waits for the next message from the Band Generation process**
  - **When a full scene has been identified, then the scene is reduced in size and displayed**
  - **Continues to process messages from the Band Generation process until a subinterval change is specified**
  - **When a subinterval change is specified, this exits**

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- **Principal Functions**
  - **Construct and transmit Data Availability Notices (DANs) to the LP DAAC**
  - **Accept Data Delivery Notices (DDNs) and automatically delete transferred output files**
  - **Provide operator override of transfer and delete functions**
  - **Generate file transfer summary report**

Manage Output File Transfer: Interfaces

- Operator commands from the MACS operations interface
- Invocation to send DAN from MACS top-level L0R program
- LPS file names from L0R subsystems via LPS database
- DAN client sessions with LP DAAC
- DDN server sessions with LP DAAC

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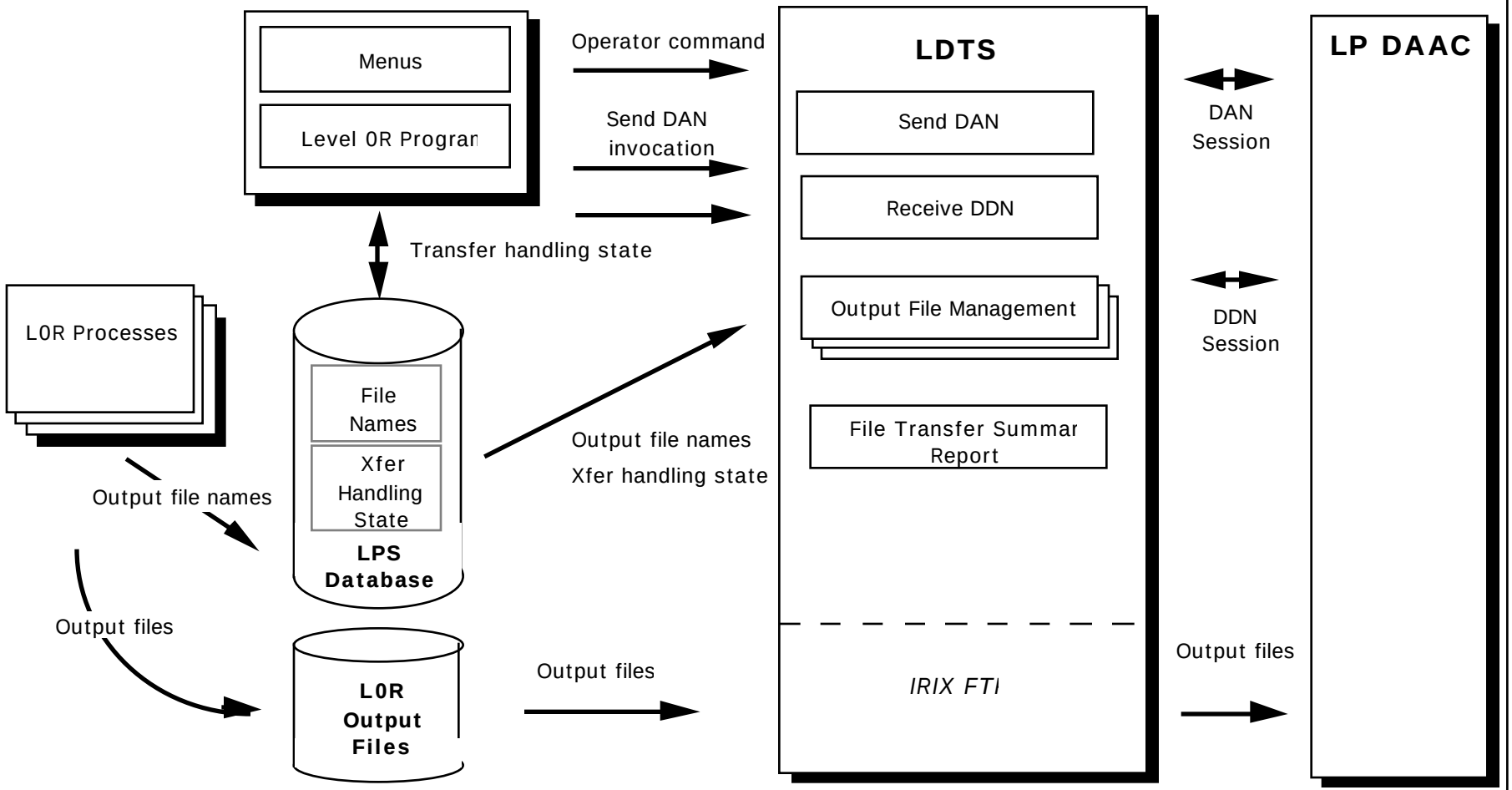
Manage Output File Transfer: Interfaces



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Manage Output File Transfer: Design (1 of 2)

- **Send DAN (ldt_SendDAN)**
  - Open client socket connection with LP DAAC
  - Authentication dialogue
  - Construct and transmit DAN (saved in text file)
  - Receive Data Availability Acknowledgment (DAA)
- **DDN server (ldt_RcvDDN)**
  - Listen for socket connection attempt
  - Authentication dialogue
  - Accept DDN
  - Send Data Delivery Acknowledgment (DDA)
  - Delete output files successfully transferred and not marked for retention
  - Log unsuccessful transfer attempts

Manage Output File Transfer: Design (2 of 2)

- **Mark output files for retention (ldt_RetainFiles)**
- **Delete output files (ldt_DeleteFiles)**
- **LPS transfer timeout watchdog (ldt_CheckTimeOuts)**
  - **Log messages announcing all DANs that have not been acknowledged within a period of time**
- **Generate File Transfer Summary Report**
  - **Accept time period (default = current day) and report output file transfer status**

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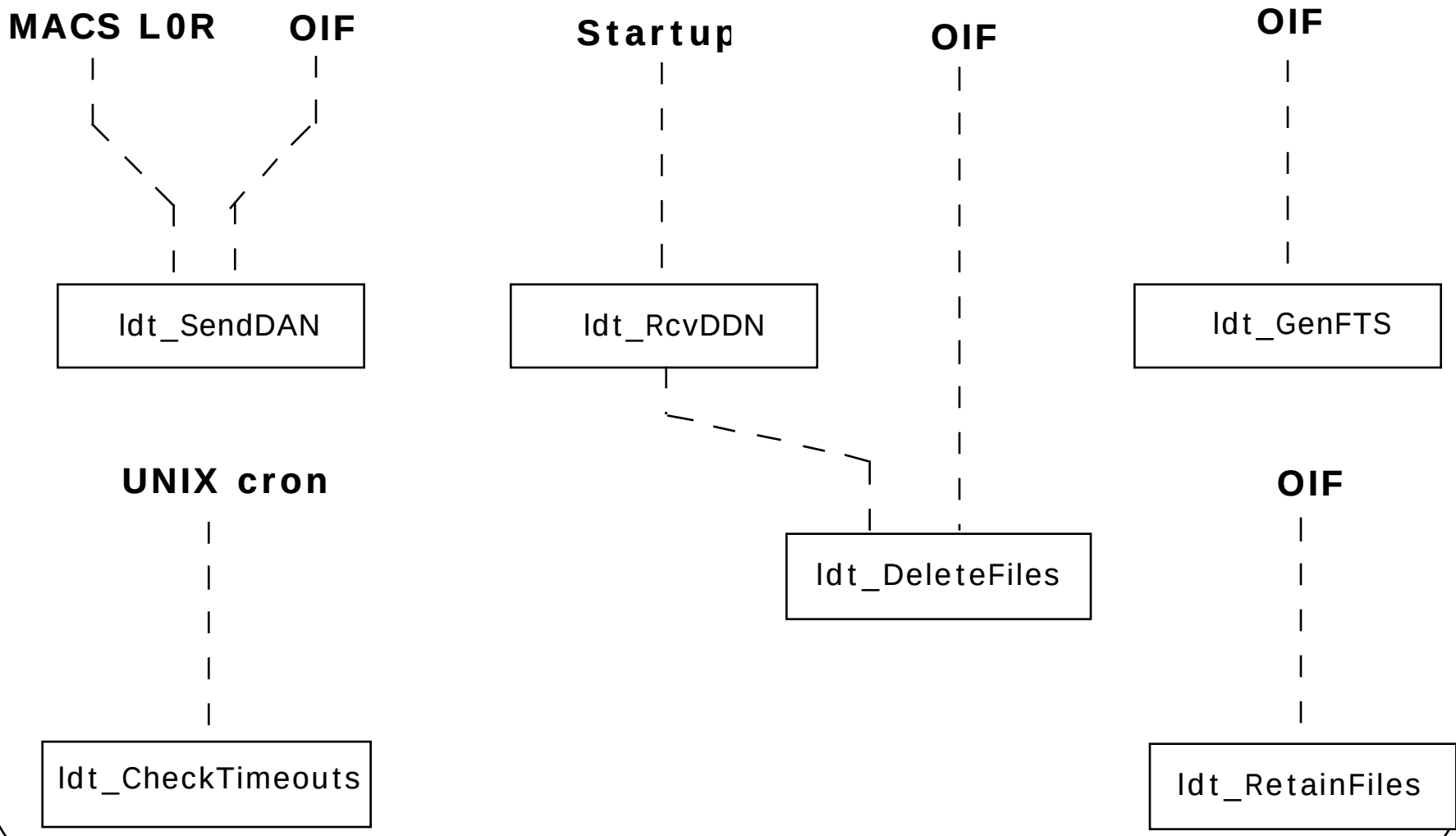
Manage Output File Transfer: Process Structure



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LPS Database: Design Approach

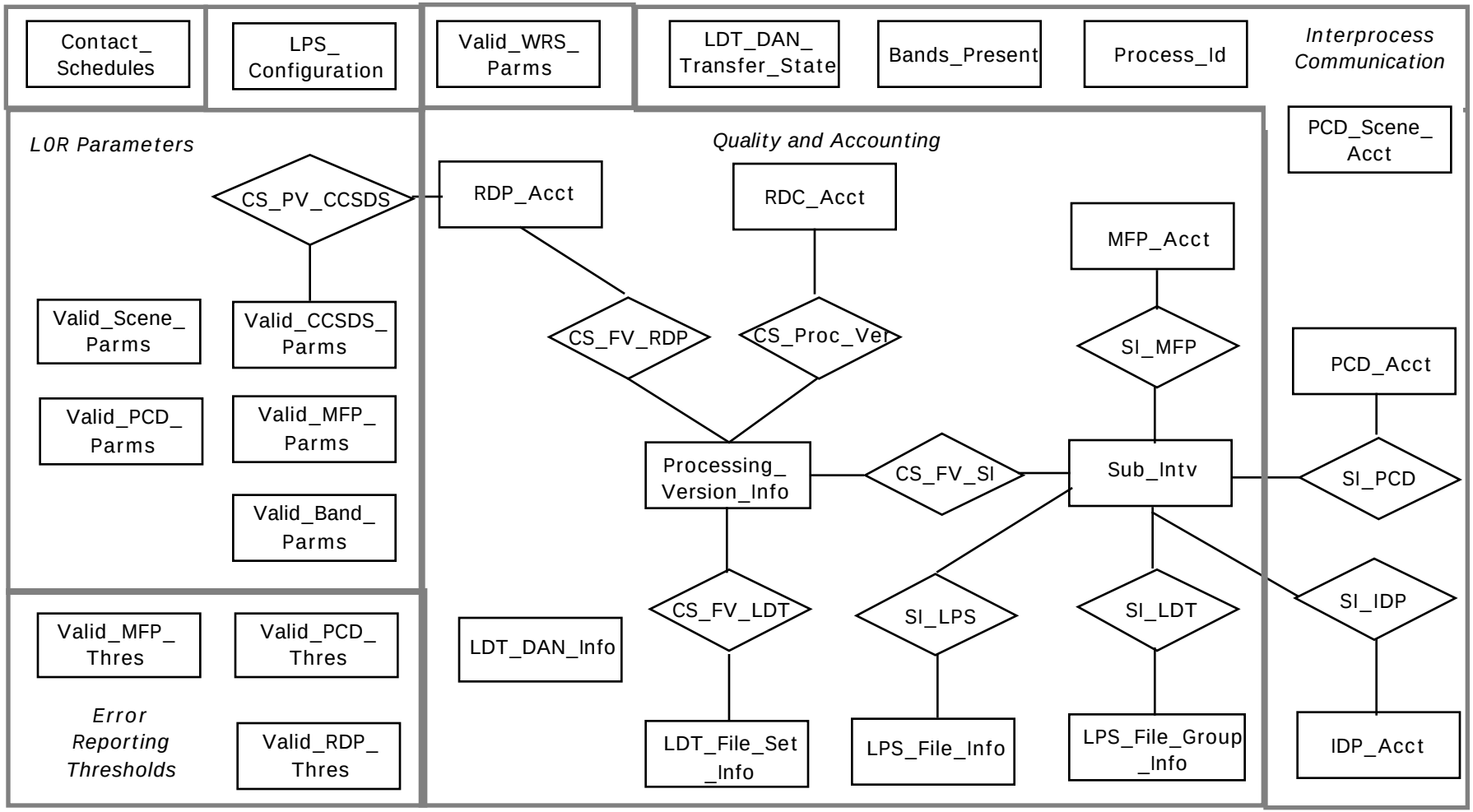
- **Logical Design**
  - Convert conceptual model (ER diagram) to relations
  - Identify keys, dependencies, and constraints
  - Normalize relations to BCNF
- **Physical Design**
  - Update CRUD table and estimate access frequencies
  - Add attributes to simplify primary keys for frequently accessed tuples
  - Add indexes to speed searches
  - Define methods for implementing each constraint
  - No denormalization was performed

LPS Database: Logical Design

- **Quality and Accounting**
  - **Raw data file accounting**
  - **L0R processing quality by subinterval and contact**
  - **Output file accounting**
- **LPS string configuration**
- **L0R parameters and error reporting thresholds**
- **Contact schedule**
- **WRS scene look-up table**
- **Inter-process communication tables**
  - **Subinterval definitions**
  - **Metadata**
  - **LPS running Process IDs and LDTS enable/disable state**

Landsat 7 Processing System CDR

LPS Database: Logical Design (2 of 2)



Landsat 7 Processing System CDR

LPS Database: Physical Design

- **Integer keys for contact and subinterval Q/A**
- **17 indexes**
- **Oracle rules enforce**
  - **Domain constraints**
  - **Not-Null restrictions**
  - **Existence constraints on foreign keys**
- **Custom integrity checks for on-line files**

- **Backups using Oracle utilities**
- **Purge using LPS custom utility**
- **Cleanup after catastrophic failure during L0R using LPS custom utility**

Landsat 7 Processing System CDR

Operations Interface: Menu Options List

- **Control**
  - **Start data capture** — **Invoke raw data capture program**
  - **Stop data capture** — **Halt raw data capture program**
  - **Start copy to tape** — **Copy raw file to removable media**
  - **Stop copy to tape** — **Halt in-progress copy operation**
  - **Start copy from tape** — **Restage raw data file**
  - **Stop copy from tape** — **Halt in-progress restage operation**
  - **Start data processing** — **Invoke L0R processing program**
  - **Stop data processing** — **Halt in-progress L0R processing**
- **Setup**
  - **LPS String Configuration** — **Update string configuration table**
  - **Data Processing Thresholds** — **Update error reporting thresholds**
  - **Data Processing Parameters** — **Update L0R parameters**
- **Test**
  - **Send data** — **Playback raw capture file**

Landsat 7 Processing System CDR

Operations Interface: Menu Options (continued)

- **Monitor**
  - Display LPS journal file — Invoke LPS journal browser
  - Display Operation Messages — Invoke real-time message display
- **Files**
  - Enable/Disable DAN Transfer — Control automatic DAN transmission
  - Resend DAN — Send DAN for set of output files
  - Retain files — Mark files for retention after transfer
  - Delete files — Delete output files
- **Reports**
  - Data receive summary — Generate data receive summary report
  - LPS QA — Generate LPS QA report
  - File transfer summary — Generate file transfer summary report
- **Shutdown** — **Exit LPS**